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Parsons Engineering Science, Inc.
1700 Broadway, Suite 900 • Denver, Colorado 80290 • (303) 831-8100 • Fax: (303) 831-8208

September 16, 1998

Major Ed Marchand
AFCEE/ERT
3207 North Road, Bldg. 532
Brooks AFB, Texas 78235-5363

Subject: Extended Bioventing Testing Results for SWMU 55 (IRP Site FT-03), Charleston AFB, South Carolina (Contract No. F41624-92-8036, Order 17)

Dear Major Marchand:

This letter presents the results of the bioventing system monitoring performed by Parsons Engineering Science, Inc. (Parsons ES) during June 1998 at Solid Waste Management Unit (SWMU) 55 (Former Fire Protection Training Area No. 3, Installation Restoration Program [IRP] Site FT-03), Charleston Air Force Base (AFB), South Carolina. Soil gas sampling for field and laboratory analyses was performed on 23 June 1998, approximately 1 month following blower shut down. *In situ* respiration testing was performed from 23 through 27 June 1998 to assess the extent of remediation achieved during approximately 4.5 years of pilot-scale system operation and 1 year of expanded-scale bioventing system operation. The purposes of this letter are to summarize site and bioventing activities to date, present the results of the June 1998 system monitoring event, compare these results with previous pilot testing and monitoring results, and to recommend future activities for the site based on these findings.

SITE REMEDIATION HISTORY

Site Description

Fire Protection Training Area No. 3, also referred to as Site FT-03 and SWMU 55, is located in the extreme southeastern part of Charleston AFB. The 2-acre site was once used for controlled burning of flammable wastes during base fire training exercises. During its operation, the facility consisted of one burn pit surrounded by an earthern berm and lined with limestone gravel (see Figure 1). A steel tank used as a mock aircraft was located inside the burn pit, and a concrete building was located outside the burn pit at the southwestern corner of the site. During fire training exercises, flammable liquids were sprayed onto these structures and the ground, ignited, and then extinguished using various agents such as aqueous film-forming foam, halon, and dry chemicals. It is reported that JP-4 jet fuel was the primary flammable liquid burned at the site; however, it is believed that other industrial wastes may have been burned when the facility was first established (Halliburton NUS, 1995).

The site has not been used for fire training exercises since the early 1980s. It is currently overgrown and heavily wooded around its perimeter. The steel tank, concrete building, and remnants of the earthen berm are still present at the site.

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Bioventing Pilot Testing

In October 1992, Parsons ES (formerly Engineering-Science Inc. [ES]) installed a bioventing pilot test system at SWMU 55 to remediate soils impacted by jet fuels, reclaimable mixed fuels, and other flammable wastes that were used during fire training exercises at the site. The pilot-scale system consisted of one 4-inch-diameter horizontal air injection vent well (VW-1), four permanent soil vapor monitoring points (MPs) (MPA, MPB, MPC, and MPD) and several temporary soil MPs installed in fuel-impacted soils on the north side of the burn pit (ES, 1993). A single 1-horsepower (HP) blower was used for the pilot-scale system. This system was operated and monitored by Parsons ES as a pilot study for 1 year, from November 1992 through November 1993. Respiration testing and soil gas sampling were performed in November 1992 (prior to system startup), and in May and November 1993 (6 and 12 months following pilot system startup, respectively). Following the 1-year pilot study, the Base operated the pilot test blower system for another 3.5 years.

Expanded-Scale Bioventing System Installation

Based on positive results from the 1-year bioventing pilot test, funding was provided by the Air Force Center for Environmental Excellence (AFCEE) to design and install an expanded system for continued bioventing treatment of vadose zone soils at SWMU 55. An expanded bioventing system consisting of one new 4-inch diameter horizontal VW (VW-2), six new MPs (MPE, MPF, MPG, MPH, MPI, and MPJ), a new blower system, and associated piping, controls, and electrical service were installed at the site. Three of the four existing permanent MPs installed during previous pilot testing efforts (MPB, MPC, and MPD) continue to be used to monitor system performance. The original pilot test VW (VW-1) also was incorporated into the full-scale system for air injection. The regenerative blower system that had been used for pilot-scale testing was shut down, dismantled and removed from the site.

The new system was installed by Parsons ES and subcontractors between 25 February and 8 May 1997, in accordance with the design described in the *Final Interim Measures Work Plan, Expanded Bioventing System, SWMU 55 (IRP Site FT-03), Charleston Air Force Base, South Carolina* (Parsons ES, 1997a). Figure 1 shows the site layout with the locations of the bioventing system components. Additional record drawings showing the final design details of the system components are provided in the operations and maintenance (O&M) manual (Parsons ES, 1997b). A summary of field activities, initial sampling results, and initial monitoring results from the 1997 event are provided in a 30 October 1997 letter to Major Ed Marchand at AFCEE (Parsons ES, 1997c).

1998 BIOVENTING SYSTEM MONITORING EVENT

The Option 1 soil gas sampling and *in situ* respiration testing were performed in June 1998. The system was shut down 1 month prior to soil gas sampling to allow soils and soil gas to come to equilibrium in order to compare initial and current conditions. The blower system was re-started and optimized following testing to continue bioventing treatment of site soils. Results of the June 1998 soil gas sampling and respiration testing at SWMU 55 are presented in this report, and compared with previous results.

Soil Gas Chemistry Results

Field screening and collection of soil gas samples for laboratory analysis were performed on 23 June 1998, following approximately 4.5 years of pilot-scale system operation, 1 year of expanded-scale system operation, and 1 month of system shutdown. Soil gas samples were collected from each MP interval (excluding MPA and MPC), and field-screened to assess soil gas concentrations of oxygen, carbon dioxide, and total volatile hydrocarbons (TVH). In addition, soil gas samples for laboratory analysis were collected from five MP screened intervals that exhibited the greatest contamination (MPE-3.2, MPF-3.3, MPG-3.3, MPH-2.8, and MPJ-3.0). For all soil gas sampling events discussed in this report, laboratory samples were sent to Air Toxics, Ltd. in Folsom, California, and analyzed for TVH and benzene, toluene, ethylbenzene, and xylenes (BTEX) using US Environmental Protection Agency (USEPA) Method TO-3. Field and laboratory soil gas sampling results from November 1992, May and November 1993, April 1997, and June 1998 are presented in Table 1 (attached).

Static oxygen concentrations in soil gas generally have increased, and TVH concentrations have decreased significantly at most sampling locations with continued air injection bioventing at the site (Table 1). The overall increases in soil gas oxygen concentrations indicate that aerobic microorganism respiration (i.e. hydrocarbon biodegradaton) rates have decreased substantially, suggesting that significant amounts of substrate (fuel hydrocarbon contamination) have been biodegraded in the soil at most locations.

Field soil gas TVH concentrations have decreased at all the MPs, and laboratory soil gas TVH and BTEX concentrations have decreased similarly. At all locations except MPE and MPG, TVH concentrations have been reduced to below 1,000 ppmv. The greatest reductions in laboratory TVH and BTEX concentrations were observed at MPH-2.8, where TVH was reduced by 99.6 percent and total BTEX was reduced by 97.6 percent. At MPE-3.2, where low-permeability soils are present, the TVH concentration was reduced by 67 percent, and the total BTEX concentration was reduced by 60 percent. These data indicate that although TVH levels at SWMU 55 remain high (above 1,000 ppmv) at two locations, both TVH and the risk-driving BTEX compounds are being biodegraded during bioventing system operation.

Soil laboratory analyses confirm previous soil gas survey results (Parsons ES, 1997c) and indicate that soil hydrocarbon contamination has not migrated far from the source area. Low oxygen and high TVH concentrations were measured in soil gas samples collected from the MPs in the southern half of the site, indicating the presence of widespread vapor-phase contamination and anaerobic conditions. The June 1998 soil gas oxygen concentration at MPB (on the north side of the burn pit) was significantly higher than during May 1993 (see Table 1). Although the northern side of the burn pit had undergone 4.5 years of pilot-scale bioventing treatment prior to operating the expanded bioventing system, limited oxygen utilization, indicative of microbial biorespiration, is still occurring in these soils.

Respiration Test Results

Respiration tests can be used as a qualitative guide to determine the degree of soil remediation that has been achieved due to aerobic biodegradation. Field respiration testing has been conducted four times during bioventing implementation at SWMU 55. The first three test events were associated with the initial bioventing pilot study and were conducted in November

1992 (prior to system startup), and in May and November 1993 (after 6 months and 1 year of pilot-scale system operation, respectively). The fourth respiration testing event was conducted in June 1998, following 30 days of shut down of the expanded-scale bioventing system. Observed rates of oxygen utilization were used to estimate aerobic fuel biodegradation rates for each respiration test. Respiration and fuel biodegradation rates for site soils are shown on Table 2.

The 1998 *in situ* respiration testing was performed at SWMU 55 from 24 through 27 June 1998. Point respiration tests were conducted at MPD-3.9, MPE-3.2, MPF-3.3, MPG-3.3, MPH-2.8, and MPI-3.0. The tests were performed according to protocol procedures (Hinchee *et al.*, 1992). The point respiration tests were performed by injecting air (oxygen) into each MP screened interval for a 16- to 20-hour period using a 1-cubic-foot-per-minute (cfm) pump. After the pump was turned off, changes in soil gas chemistry at each MP were measured for at least 3 days.

As can be seen in Table 2, significant reductions had occurred in respiration and fuel biodegradation rates at MPA and MPB between 6 months and 1 year of pilot-scale system operation. MPD-3.9 is the only location that has been tested during each sampling event since pilot system startup in November 1992. The oxygen utilization rate at MPD-3.9 has decreased by 72 percent from November 1992 to November 1993, indicating that the lighter, more readily biodegradable hydrocarbons were preferentially destroyed during the initial year of pilot-scale system operation (November 1992 through November 1993). The oxygen utilization rate at MPD-3.9 has remained fairly constant between November 1993 and June 1998, indicating that more biologically recalcitrant, higher-molecular-weight hydrocarbons remain in site soils approximately 5.5 years after initiating air injection in the vicinity of MPD. During the June 1998 respiration testing, fuel biodegradation rates ranged from 220 mg/kg/year at MPI-3, to 1,940 mg/kg/year at MPE-3.2 (Table 2). The slow biodegradation rates at most locations (<300 milligrams of fuel per kilogram of soil per year) correspond to the low TVH concentrations measured after 1 month of system shutdown at these locations (Table 1).

CONCLUSIONS AND RECOMMENDATIONS

Based on the June 1998 data, residual BTEX and TPH compounds in soils at SWMU 55 have been greatly reduced as the result of bioventing remediation. Although aerobic biodegradation rates are still significant at several locations, soil gas conditions indicate that the discrete contaminant interval, located from the ground surface to the water table (at a depth of approximately 4 feet below ground surface), is being treated by air injection bioventing. Static oxygen concentrations may remain deficient (<5 percent) throughout some of the site without continued bioventing; however, soil gas TVH and BTEX concentrations are very low at most locations (Table 1), indicating that little residual fuel contamination remains to be treated. Therefore, it is recommended that the Air Force proceed with confirmation soil sampling pursuant to closure of the soil unit at this site. At MPE-3.2, which is located within clayey backfill material, soil gas TVH and BTEX concentrations are still elevated; therefore, a soil sample will be collected from this area during confirmation soil sampling to determine current soil contaminant levels.

Parsons ES recommends that Charleston AFB continue to operate the existing bioventing system until site closure is granted, or until a no-further-response-action-planned (NFRAP) agreement is reached with the South Carolina Department of Health and Environmental Control. Sustained bioventing system operation will continue to oxygenate soils and enhance aerobic biodegradation of residual petroleum hydrocarbon contamination that could leach from the contaminant zone. In addition, continued bioventing system operation will promote oxygen delivery to the saturated zone through diffusion.

A Draft Confirmation Soil Sampling and Analysis Plan for SWMU 55 has been prepared and will be delivered shortly. Soil sampling activities are expected to take place in November 1998. A Draft Confirmation Sampling Report for SWMU 55 will be prepared following receipt of laboratory analytical data.

If you have any questions or require additional information, please contact Mr. Dave Teets, the new Parsons ES site manager, at (406) 254-6533, or Mr. John Ratz, the Parsons ES project manager, at (303) 831-8100.

Sincerely,

PARSONS ENGINEERING SCIENCE, INC.

John Ratz for DBT

David Teets
Site Manager

John Ratz

John Ratz, P.E.
Project Manager

Attachments

cc: Mr. Keith Thompson, 437 CES/CEV (Charleston AFB, South Carolina)
Mr. Al Urrutia, 437 CES/CEV (Charleston AFB, South Carolina)
File 727876.28210.E Letter Results Report

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Parsons Engineering Science, Inc. 1997a. *Final Interim Measures Work Plan, Expanded Bioventing System, SWMU 55 (IRP Site FT-03).* Charleston AFB, South Carolina. April.

Parsons Engineering Science, Inc. 1997b. *Operations and Maintenance Manual for Expanded Bioventing System, SWMU 55 (IRP Site ST-03).* Charleston AFB, South Carolina. October.

Parsons Engineering Science, Inc. 1997c. Letter report summarizing initial results for the expanded bioventing system installed at SWMU 55 (IRP Site FT-03), Charleston AFB, South Carolina. October 30.

TABLE 1
SOIL GAS FIELD AND LABORATORY ANALYTICAL RESULTS
SWMU 55 (SITE FT-03)
CHARLESTON AFB, SOUTH CAROLINA

			Field Screening Data			Laboratory Analytical Data[a/]				
Sample Location	Sample Depth (ft bgs)[b/]	Sampling Date	Oxygen (percent)	Carbon Dioxide (percent)	TVH (ppmv)[c/]	TVH (ppmv)	Benzene (ppmv)	Toluene (ppmv)	Ethyl-benzene (ppmv)	Xylenes (ppmv)
MPA	3.5	11/92	0.0	8.2	5,000	---[d/]	---	---	---	---
		5/6/93	---	---	---	27	0.002U[e/]	0.002U	0.002U	0.002U
		11/11/93	---	---	---	0.47	0.002U	0.002U	0.002U	0.002U
MPB	3.5	11/92	0.0	7.8	1,400	---	---	---	---	---
		4/25/97	18.5	0.8	170	---	---	---	---	---
		6/23/98	14.3	8.4	32	---	---	---	---	---
MPC	3.25	11/92	0.0	6.3	200	---	---	---	---	---
		11/11/93	---	---	---	0.78	0.002U	0.002U	0.002	0.002U
		4/25/97	10.5	1.8	140	---	---	---	---	---
MPD	3.9	11/92	0.0	8.4	>20,000[f/]	---	---	---	---	---
		5/6/93	---	---	---	790	0.04U	0.04U	0.12	0.22
		11/11/93	---	---	---	13	0.002U	0.002U	0.002U	0.002U
		4/25/97	15.2	1.5	140	---	---	---	---	---
		6/23/98	5.0	13.9	76	---	---	---	---	---
MPE	3.2	4/25/97	0.5	8.0	4,200	10,000	20M[g/]	120M	31	36
		6/23/98	2.0	>25	3,600	3,300	1.9	0.35U	21	60M
MPF	3.3	4/25/97	0	7.8	2,000	3,000	4	7.6	16	27M
		6/23/98	0	15.0	180	100	0.17	0.0095U	0.32	1.4M
MPG	3.3	4/25/97	2.0	7.0	5,600	9,600	25M	100M	37	90
		6/23/98	0	19.0	1,080	950	0.2	0.080U	6.5	17M
MPH	2.8	4/25/97	3.4	6.5	8,200	8,200	47	14	9.5	22M
		6/23/98	0	13.0	90	36/35	0.18/0.18	0.0029U/ 0.0029U	0.46/0.45	1.8M/1.7M
MPI	3.0	4/25/97	0.8	7.0	5,400	---	---	---	---	---
		6/23/98	10.9	9.2	30	---	---	---	---	---
MPJ	3.0	4/25/97	2.2	7.5	4,800	6,300	24	14	3	5.2
		6/23/98	3.9	19.0	110	85	0.23	0.012U	0.092	0.25M
MW3-13	5.8-7	4/25/97	0	4.3	8,000	---	---	---	---	---
		6/23/98	0.9	18.0	220	---	---	---	---	---

[a/] Laboratory analysis of soil gas performed using USEPA Method TO-3, referenced to jet fuel (molecular weight = 156).

[b/] ft bgs = feet below ground surface.

[c/] TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume.

[d/] --- = not analyzed.

[e/] U = compound analyzed for , but not detected. Number shown represents the laboratory method detection limit.

[f/] > = denotes field measurement greater than maximum meter reading.

[g/] M = Laboratory reported value may be biased due to apparent matrix interferences.

TABLE 2

RESPIRATION AND FUEL BIODEGRADATION RATES

SWMU 55 (SITE FT-03)

CHARLESTON AFB, SOUTH CAROLINA

Sampling Location-Depth (feet bgs)[a/]	Pilot-Scale Test						Expanded-Scale Operation	
	Initial Results (November 1992)		6-Month Results (May 1993)		1-Year Results (November 1993)		Most Recent Results (June 1998)	
	O_2 Utilization (% O_2/hour)	Biodegradation Rate[b/] (mg/kg/year)[f/]	O_2 Utilization (% O_2/hour)	Biodegradation Rate[c/] (mg/kg/year)	O_2 Utilization (% O_2/hour)	Biodegradation Rate[d/] (mg/kg/year)	O_2 Utilization (% O_2/hour)	Biodegradation Rate[e/] (mg/kg/year)
MPA-3.5	---[g/]	---	0.276	270	0.051	120	---	---
MPB-3.5	---	---	0.108	110	0.027	60	---	---
MPC-3.25	---	---	---	---	0.022	70	---	---
MPD-1.8	---	---	0.186	370	0.168	510	---	---
MPD-3.9	0.528	580	0.84	1,690	0.15	450	0.120	240
MPE-3.2	---	---	---	---	---	---	1.99	1,940[h/]
MPF-3.3	---	---	---	---	---	---	0.361	730
MPG-3.3	---	---	---	---	---	---	0.774	1,560
MPH-2.8	---	---	---	---	---	---	0.118	240
MPI-3.0	---	---	---	---	---	---	0.108	220

[a/] bgs = below ground surface.

[b/] Assumes moisture content of the soil is equal to the initial results at MPD-3.

[c/] Assumes moisture content of the soil is equal to the average initial (1992) and 1-year (1993) results.

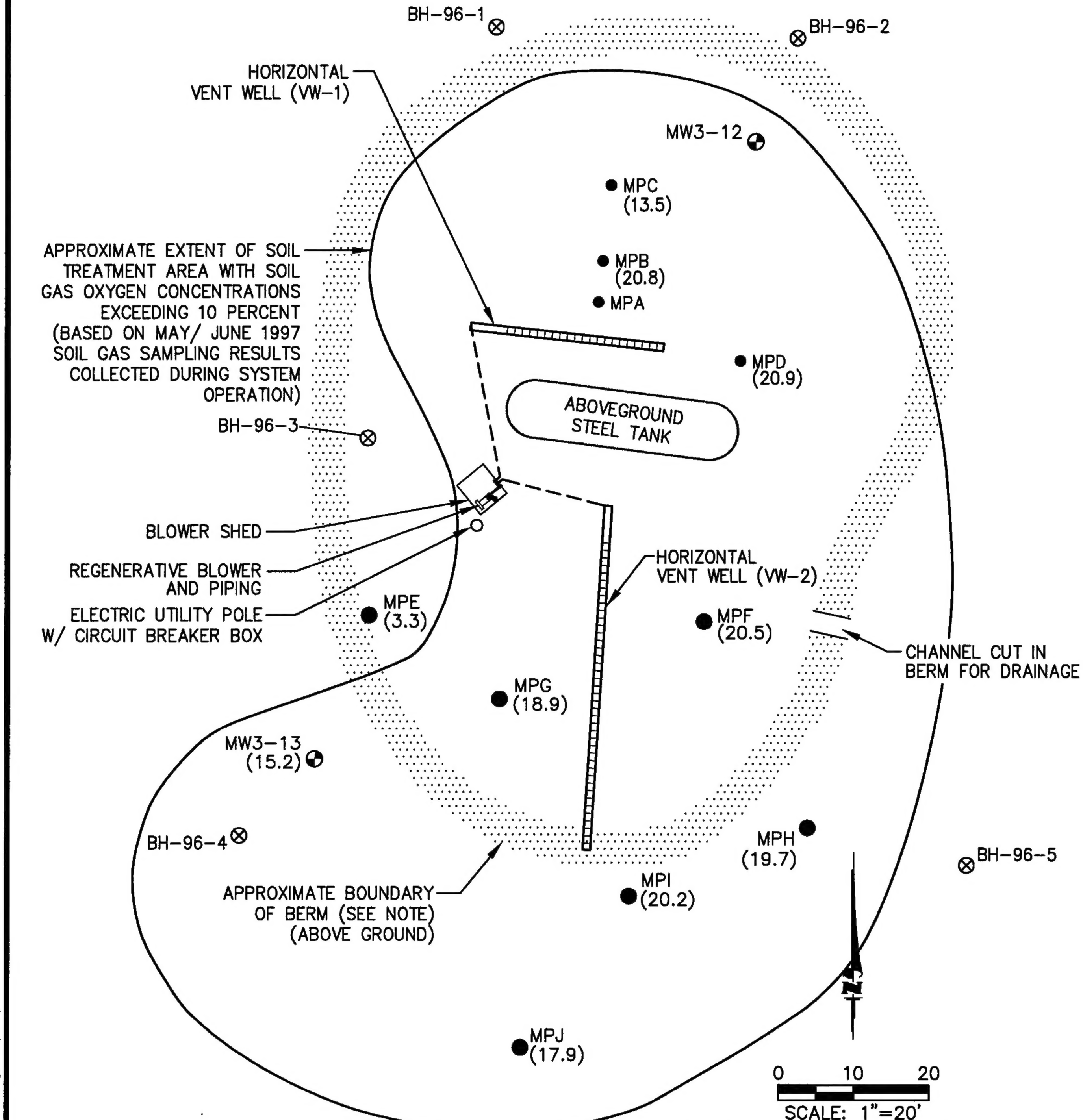
[d/] Assumes moisture content of the soil is equal to the 1-year (1993) results.

[e/] Moisture content is estimated to be 9.6%, based on sample results from nearby vapor MPs.

[f/] Milligrams of hydrocarbons per kilogram of soil per year.

[g/] --- = Respiration test not conducted.

[h/] Moisture content is estimated to be 12.6%.



LEGEND

MW3-12	GROUNDWATER MONITORING WELL
MPF	SOIL VAPOR MONITORING POINT
(20.5)	SOIL GAS OXYGEN CONCENTRATION (%)
BH-96-5	SOIL BORING/ SAMPLING LOCATION
– – – – –	AIR INJECTION HEADER PIPE (BURIED)

NOTE:
SOIL BERM HAS APPROXIMATE ELLIPTICAL DIMENSIONS AND VARYING WIDTHS, LOCATIONS OF TANK, VENT WELLS, AND UTILITY POLE WITHIN BERM ARE ESTIMATED.

FIGURE 1

SITE PLAN AND BIOVENTING SYSTEM LAYOUT

SWMU 55 (Site FT-03)
Charleston AFB, South Carolina

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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